Overview of Microcomputer Structure and Operation

Department of Computer Science & Engineering
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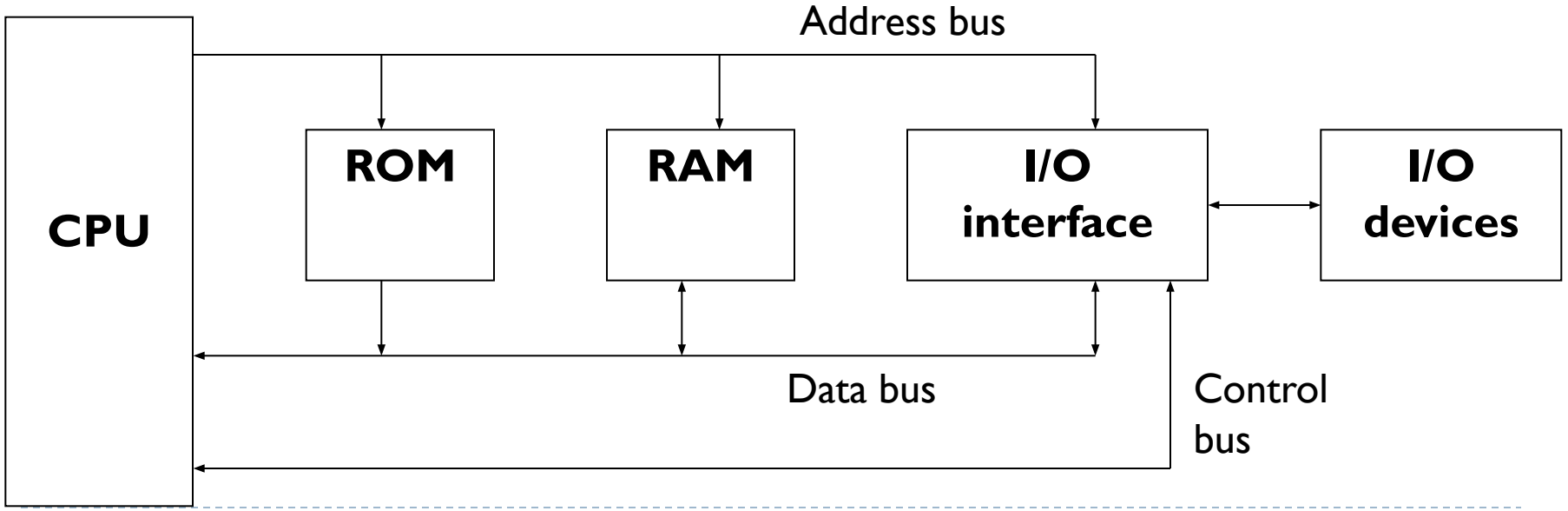
Course ID: CSE - 341
Course Title: Microprocessors

Block Diagram of a Microcomputer

Components of Microcomputer:

- CPU (Microprocessor)
- Memory (RAM, ROM etc.)
- I/O
- System Buses:
  - Address bus
  - Data bus
  - Control bus



CPU - Central Processing Unit

- **FETCH :** Take in binary-coded instructions from memory
- **DECODE :** Analyze or make sense of the instructions
- **EXECUTE :** Carry out the instructions
- Controls overall operation of the computer

- **Three components of CPU:** Registers , ALU , Control Unit.

Pentium D dual core processors

Primary memory	Secondary memory
Primary memory is temporary.	Secondary memory is permanent.
Primary memory is directly accessible by Processor/CPU.	Secondary memory is not directly accessible by the CPU.
Nature of Parts of Primary memory varies, RAM- volatile in nature. ROM- Non-volatile.	It's always Non-volatile in nature.
Primary memory devices are more expensive than secondary storage devices.	Secondary memory devices are less expensive when compared to primary memory devices.
The memory devices used for primary memory are semiconductor memories.	The secondary memory devices are magnetic and optical memories.
Primary memory is also known as Main memory or Internal memory.	Secondary memory is also known as External memory or Auxiliary memory.
Examples: RAM, ROM, Cache memory, PROM, EPROM, Registers, etc.	Examples: Hard Disk, Floppy Disk, Magnetic Tapes, etc.

What does it means to be Volatile

- Memories which can store data as long as there is a power supply.
- As soon as the power connection is lost the data is automatically erased.
- Volatile memory is temporary
- Eg: RAM, registers.

Scenario: Let's say you are playing a game on pc (game that is being played is on RAM). You experience a power cut and then restart the computer again. Will the game RESUME from you left off?
Ans: No

Which primary memory is Non - Volatile

ROM

All other primary memories are VOLATILE

Memory

- This is where all the binary coded instructions and data are stored. Example: ROM, RAM etc.

RAM (Random Access Memory) :

- Can be read and written to anytime by the CPU.
- It is volatile memory. That means contents of RAM are erased when the power to the computer is turned off.

ROM (Read Only Memory) :

- Can only be read by the CPU.
- It is pre-loaded with data and software that never changes like computer's initial start-up instructions. (BIOS)
- It is non volatile memory. That means contents of ROM are **NOT** erased when the power to the computer is turned off.

Practice Question

1) Let's say we remove the slow secondary memory (HDD) and store everything in primary memory (RAM), is there any issue in that?
2) What is the issue with replacing the

I/O Unit

- **Input/output (I/O) units serve as a medium of communication between the user and the computer.**

- **Inputs** are the signals or data received by the system, and **outputs** are the signals or data sent from it.
- Devices that provide input or output to the computer are called ***peripherals***.
- For example:

  keyboard, **mouse** (input)

  display, **printer(**output**)**

I / O interface - Mouse port

I / O device - Mouse

System Bus

- System bus is made up of three types of bus :
  - Address Bus
  - Data Bus
  - Control Bus

- **WRITE operation :** When data is written onto memory location or an I/O port by the processor
- **READ operation :** When data is read from a selected memory location or an I/O port by the processor

^ From the perspective of the processor Always

Address Bus

- Carries memory address(location) of the instructions which are to be executed from processor to memory or I/O devices
- Information transfer ONLY takes place from the processor to the memory or I/O elements.
- That is why address bus is ***Unidirectional***.
- The number of locations that the CPU can address is determined by the size of address bus

For example : microprocessor with 32 bit address bus can address 2^{32} memory locations (Highest Memory supported - 4GB)

32-bit CPU

Address Bus Size - 32 bit

Data Bus Size - 32 bit

NB: The size of address is NOT 2^{32}

Maximum Memory(RAM) 32 bit Address bus can addressed/supported -

- $2^{32} = 4.29 \times 10^9$ Bytes
- $4.29 \times 10^9 / (1024)^3 = 4$ GB (GigaBytes)
- Anything more than than is not accessible or usable.

Conversion Essential

1 KByte = 1024 Byte

1 MByte = 1024 x 1024 = $(1024)^2$ Byte

1 GByte = $(1024)^3$ Byte

- 32 bit can support → Maximum 4 GB supported

Q) What happens when we have a 16 GB RAM with an address bus of 32 bit ? Ans: 4GB utilized. 12 GB not used

Q) What happens when we have a 3 GB RAM with an address bus of 32 bit? Ans: Entire 3 GB is utilized

Data Bus

- It is used to carry data. ONLY data
- It is a **bidirectional.** That means data can flow in both to or from the microprocessor.
- The size of the data bus varies from one microprocessor to another.
- Usually matches the *word length* of the microprocessor

* Instructions are also data

Q) What is the size of address or data bus for a 20 bit CPU?

- → Size of address or data bus both is 20 bit.

Q) How much maximum RAM can a 20 bit CPU handle?

Address bus - Max Memory supported

Data bus - Word length

Control Bus

- It carries timing and control signals generated by the CPU that are used to synchronize operation of the individual microcomputer elements.

- It can carry many different signals. For e.g.
  - I/O Read
  - I/O Write
  - Interrupt
  - Memory read
  - Memory write

Fetch & Execute Cycles

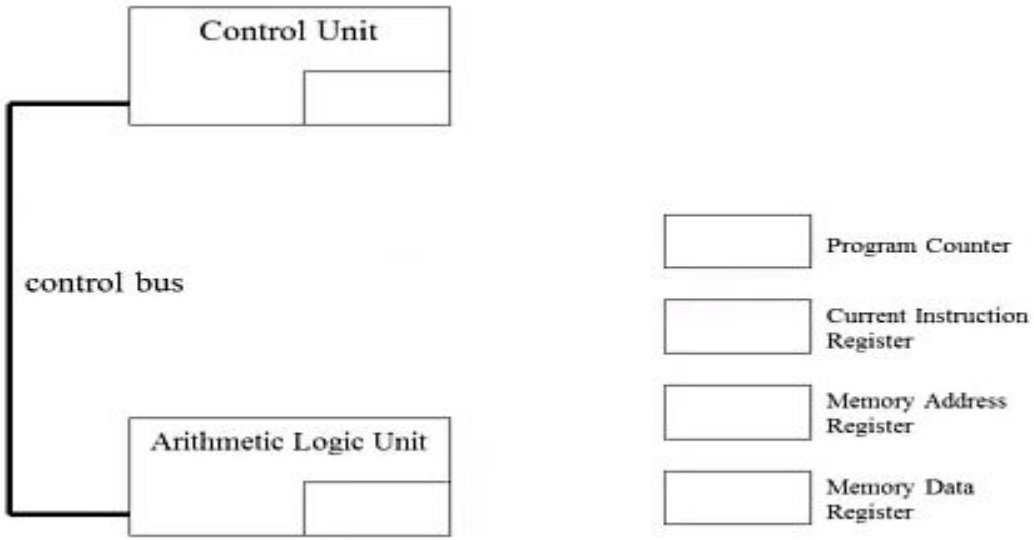
The Fetch & Execute Cycle of the CPU is composed of three basic operations :

- **Fetch**
- **Decode**
- **Execute**

- **Fetch :**
  - The instruction required from memory is stored or copied in the instruction register.
  - Increments the program counter so that it points to the next instruction.

The CPU's Special Purpose Registers

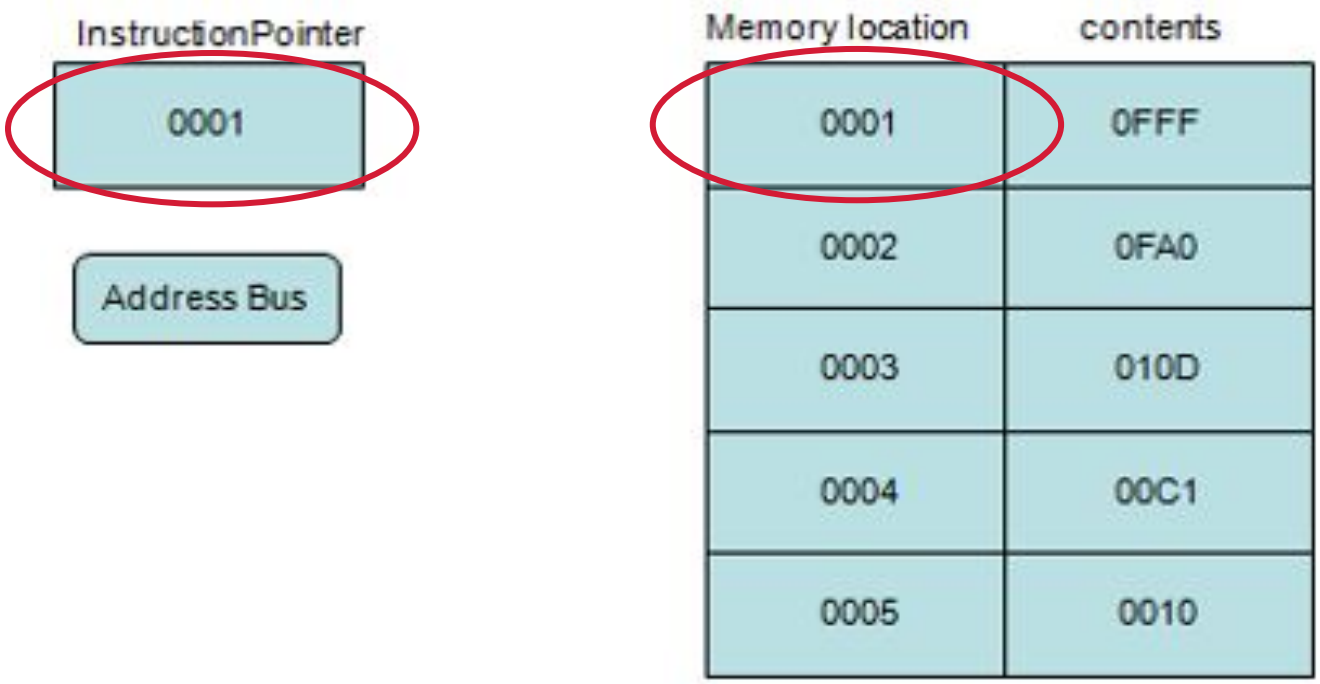
- **Program Counter / Instruction Pointer (IP)** : Holds address of next instruction
- **Instruction Register** : Holds the instruction currently being executed or decoded
- **Memory Address Register :** Holds memory address from where data will be fetched
- **Memory Data Register** : Holds the data being transferred to the memo



Fetching an Instruction

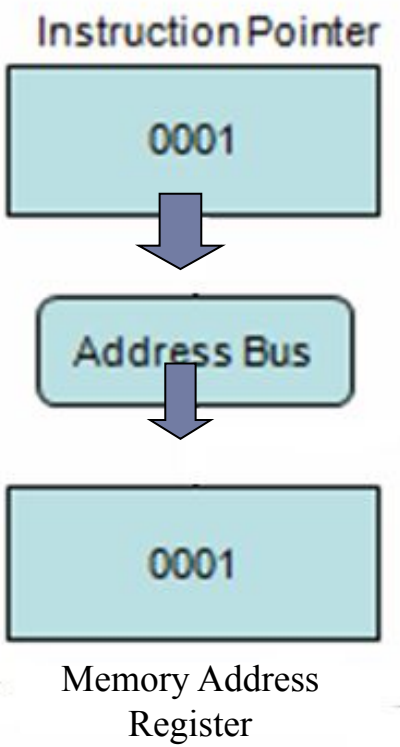
- **Step 1**

Program Counter or instruction pointer (IP) is a register that holds the address of the next instruction to be fetch.



Fetching an Instruction

- **Step 2**

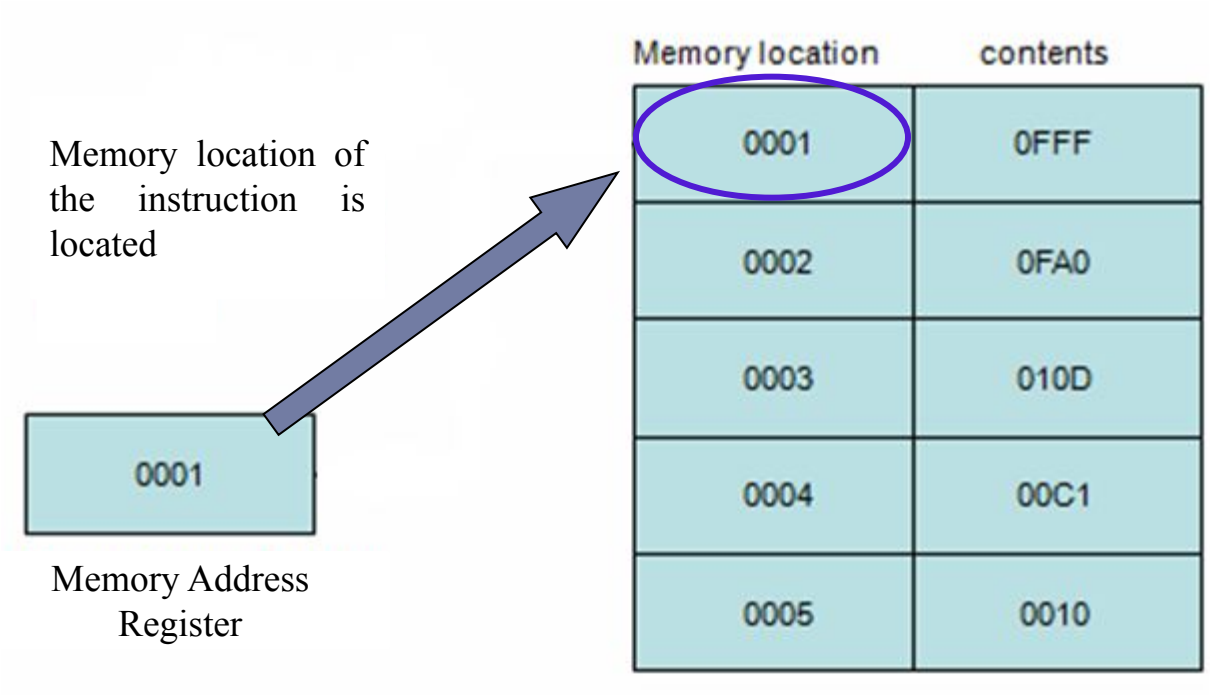


The address moves over the address bus to the Memory Address Register

Memory location	contents
0001	0FFF
0002	0FA0
0003	010D
0004	00C1
0005	0010

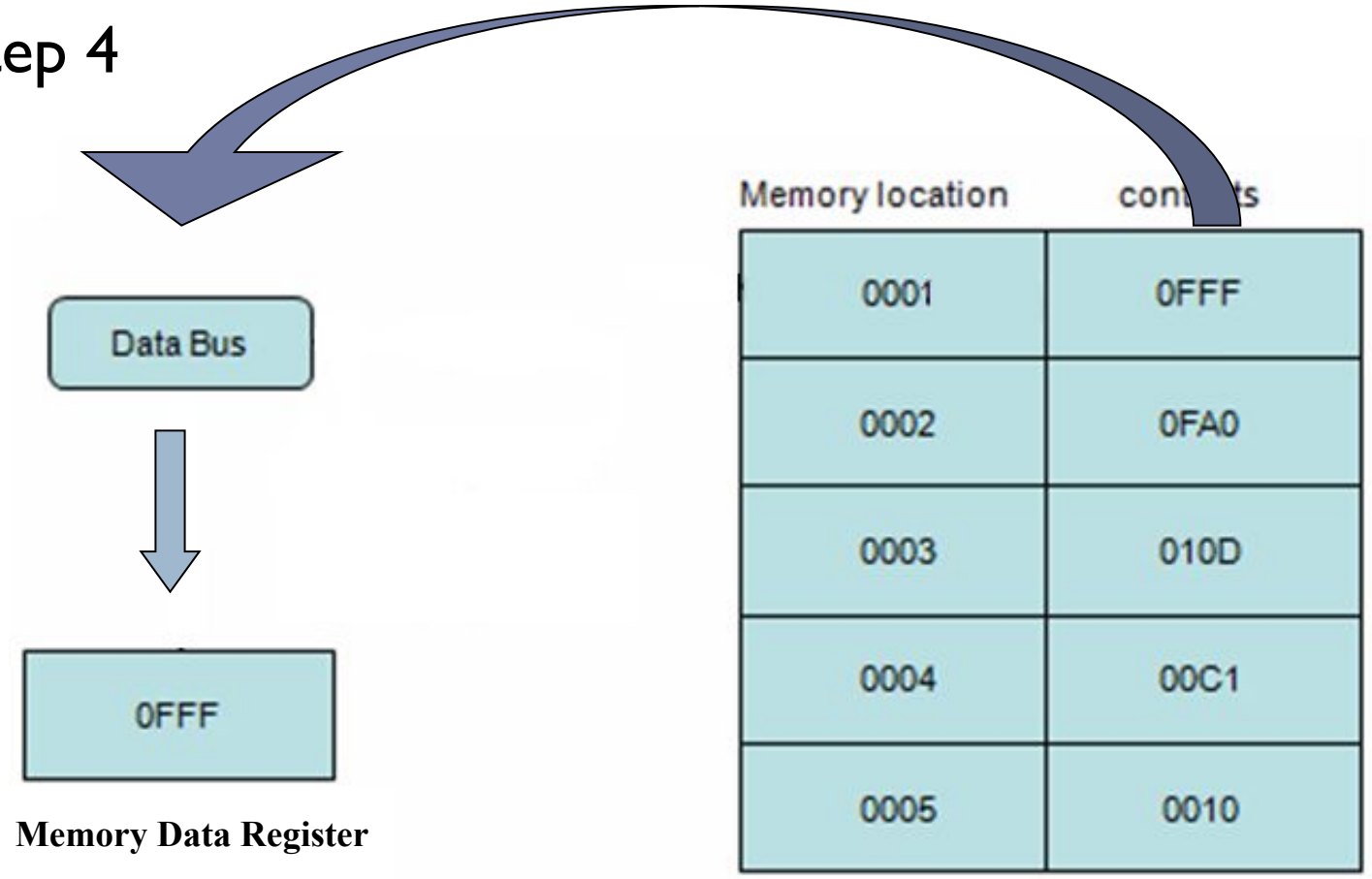
Fetching an Instruction

- **Step 3**



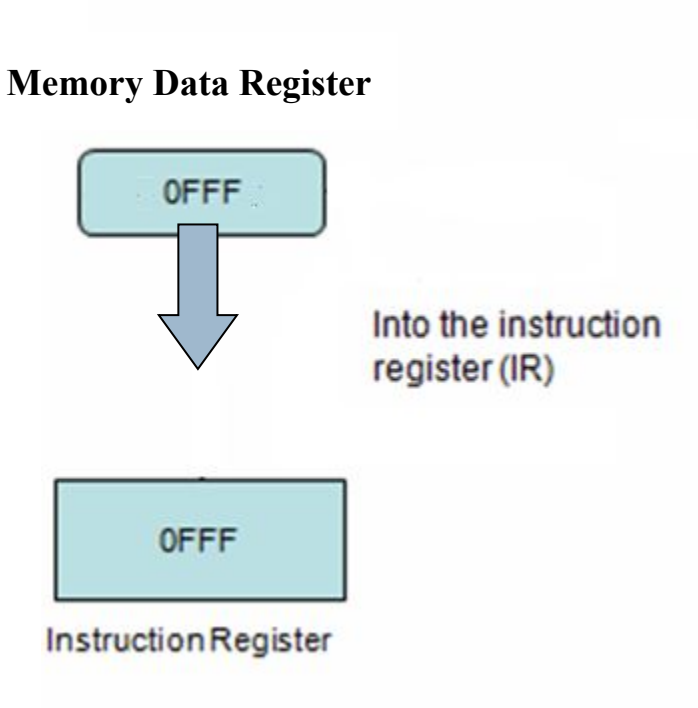
Fetching an Instruction

- Step 4



Fetching an Instruction

- Step 5



Memory location	contents
0001	0FFF
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Food for thought

- What do you mean by a 32 bit Data Bus ?
- BIOS is a special program that orchestrates loading the computer's operating system. Should it be stored in ROM or RAM ?